

On laser sensor image fringe detection and mitigation in real-time processing based on firmware supported Hilbert-Huang Transform for 2-Dimensions

Completed Technology Project (2014 - 2015)



Project Introduction

In physics, interference is a *phenomenon* in which two waves superimpose to form a new complex wave and *fringes* are observed wherever the two or more waves overlap. *Fringe analysis* has a wide range of applications in physical and engineering *measurements interpretation* and its state-of-the-art *static* processing is using linearity-assumed Fourier Transform that is inadequate due to fringe non-linear and non-stationary nature. This breakthrough technology for *optical testbed* verification experiments and fringe analysis, as well as *phase unwrapping* of spaceflight grade optical components and systems, is based on *firmware supported dynamic near real-time* Hilbert-Huang Transform for 2-dimensions (*HHT2-Fringe*).

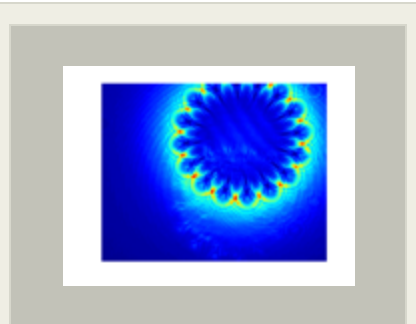
The image of a laser source through quartz substrate of the filter wheel or enclosure on the CCD detector is prone to *unwanted interference fringes* due to the impurities of quartz material. Applying antireflection coatings on both sides of the substrate could substantially reduce these fringes but does not remove them completely. Alternatively, the interference fringes analogous to Moire pattern could be removed *statically using image processing* after the in-situ measurement or *dynamically* while an experiment is in process. It's highly beneficial to eliminate these patterns dynamically using a near-real time processing. The benefit is due itself to the dynamic and nonlinear nature of these fringes where the beam source location could change at any angle. However, the static fringe analysis is using linearity-based Fourier Transforms and the *dynamic fringe analysis techniques are in embryonic state*.

One innovative approach to detect and remove the unwanted fringes dynamically is by applying the combination of the Empirical Mode Decomposition (EMD2) and the Hilbert Spectral Analysis (HSA2) for 2-dimensions and specifically researching and developing the HHT2 into fringe detection and mitigation engineering tool *HHT2-Fringe*. The EMD2 and HSA2 comprise the Hilbert-Huang Transforms for 2-dimensions or HHT2 that was recently accomplished within the Goddard internal research and development program (IRAD). The HHT2 is designed specifically for analyzing data from nonlinear and non-stationary processes in 2-dimensions.

Anticipated Benefits

This project improves development and testing of optical instruments by detecting instrument sensor fringes and their composition. This is done in firmware-assisted software analysis HHT2-Fringe technology in real-time. The technology is applicable to the development and testing of the JWST and WFIRST mission optics.

This project benefits future image radiometry missions now in planning phase.



HHT2-Fringe detectable fringes

Table of Contents

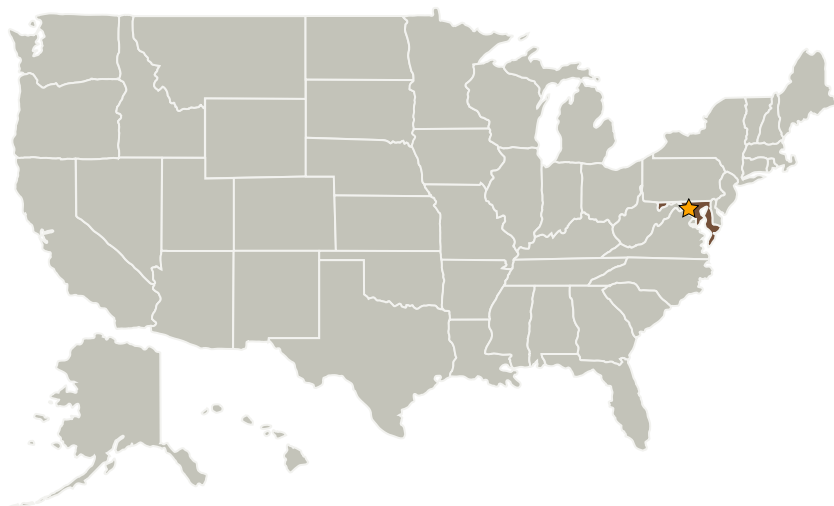
| | |
|--|---|
| Project Introduction | 1 |
| Anticipated Benefits | 1 |
| Primary U.S. Work Locations and Key Partners | 2 |
| Organizational Responsibility | 2 |
| Project Management | 2 |
| Technology Maturity (TRL) | 2 |
| Images | 3 |
| Links | 3 |
| Project Website: | 3 |
| Technology Areas | 3 |

On laser sensor image fringe detection and mitigation in real-time processing based on firmware supported Hilbert-Huang Transform for 2-Dimensions

Completed Technology Project (2014 - 2015)



Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|--------------------------------------|-------------------|-------------|---------------------|
| ★ Goddard Space Flight Center (GSFC) | Lead Organization | NASA Center | Greenbelt, Maryland |

Primary U.S. Work Locations

Maryland

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

Project Manager:

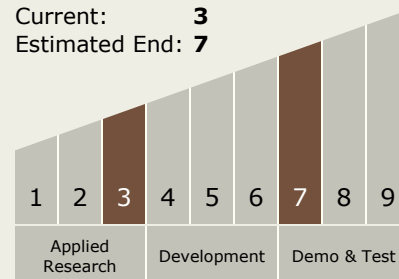
Wesley A Powell

Principal Investigator:

Semion Kizhner

Technology Maturity (TRL)

Start: 3
Current: 3
Estimated End: 7

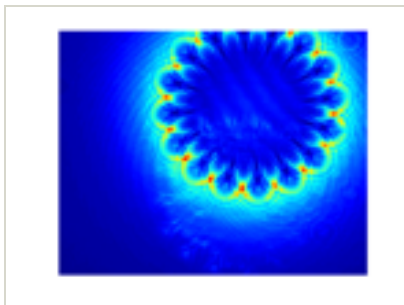


On laser sensor image fringe detection and mitigation in real-time processing based on firmware supported Hilbert-Huang Transform for 2-Dimensions

Completed Technology Project (2014 - 2015)



Images



HHT2-Fringe Technology

HHT2-Fringe detectable fringes
(<https://techport.nasa.gov/image/4172>)

Links

NTR 1436814366
(no url provided)

Project Website:

<http://aetd.gsfc.nasa.gov>

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
 - └ TX12.4 Manufacturing
 - └ TX12.4.2 Intelligent Integrated Manufacturing